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It is still to be seen whether any such providential measures will be adopted by the State of Michigan, the State that at present has more extensive lumber interests than any other in the Union. Should the subject receive serious attention at the hands of our legislators, there are two things that deserve special consideration—First, the fact that it is possible now, at slight expense, to retain under the direct control of the State, extensive areas of land, valuable for the purposes of forestry, that, so far as can now be seen, are worthless for anything else; second, *the exact facts that we must have in order to determine what to plant on the pine barrens of this State will have to be ascertained by actual experimental planting on those barrens,* and the sooner such experiments are instituted the sooner we may hope for the restoration, in part at least, of the forest wealth of the State.

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ORGANIC PHYSICS.

BY CHARLES MORRIS.

(Continued from page 148.)

THE difference in character between different muscles becomes here a matter of importance, since each muscle is thus adapted to its special duty. In the striated voluntary muscles only those fibers respond which are directly acted upon by nerve energy. But their response is rapid and vigorous, so as to produce quick, energetic and localized motions. In the smooth muscles of the intestinal canal irritation yields a less vigorous result. But in them the energy is gradually communicated from fiber to fiber, so that a progressive muscular action arises, yielding the peculiar motion known as peristaltic. In the former case the fibers are energetic, but are insulated. In the latter they are less vigorous, but are in a degree uninsulated. In the muscles of the heart both these conditions exist. Its muscles are of the striped variety, and are very energetic. They are also completely uninsulated. The fibers are destitute, or nearly so, of sarcolemma, and inosculate with each other, so as to form an intricate fibrous network. This seems the most effective of all muscular arrangements for vigorous action. There is not only quick, but general response to every nerve excitation, though brought by but a single fiber. A slight impulse brought to a single muscle fiber is immediately disseminated throughout the heart, causing general and powerful contraction. The chemical action is explosive, as in gunpowder touched by fire. It seems a special arrangement for the production of energetic action from slight contact influence.

There are other interesting features in this action of the heart. Each of its divisions is insulated from the others. The contraction of the auricles cannot be communicated to the ventricles, since they have no nervous or muscular connection. Each acts singly and successively. When the blood rushes from the vena cava into the auricle the muscles of the latter are relaxed, and the cavity readily receives the current. But the pressure of this inflowing blood affects the nerves in the walls of the cavity, quick and powerful muscular contraction ensues, and the blood is driven onward into the ventricle. The auricle, emptied of its blood and relieved from pressure, immediately relaxes. At the same time the ventricle similarly affected, contracts in like manner, and drives the blood into the arteries. The ventricle relaxes as the arteries contract, in response to a like influence. Thus by successive contractions and relaxations, induced by pressure of the blood current upon the nerve extremities, it is driven in successive pulses throughout the body.[1]

The heart has no opportunity for the long intervals of repose enjoyed by the remainder of the body. It, in company with the respiratory muscles, must be continually active. And yet it must have its intervals of sleep, however brief they be. If repair cannot accompany waste, it must have an opportunity to succeed it. The muscles of the heart have a sleeping and a waking period with every successive pulse. Contact with the blood current awakes them to action, rapid oxidation takes place, and at the same time nutrient molecules may exude from their blood capillaries into the tissues. With the cessation of the blood pressure the muscle cells sink again into repose, rapid nutrition takes place, while the products of previous oxidation are carried away, and new oxygen stored up within the cells.

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[1] The well-known fact that the heart of cold-blooded animals will continue to beat for a considerable period, when removed from the body, emptied of blood, and even nearly exhausted of moisture by desiccation, seems to militate against the above idea. Yet in such a condition air contact may replace liquid contact, while the pressure of the indurated membranes upon the nerve extremities may be sufficient to cause nerve and muscle action. It is known that the touch of cold air will induce peristaltic motion in the intestines when emptied of food. It is also known that the partly dried heart, when its contractions have ceased, may be made to resume them by a slight touch, thus showing the long continued sensitiveness of its nerves to contact.

Such is the systole and diastole of the whole system. Life has its instigating and governing agency in the contact of foreign matter with nerve extremities, the consequent oxidation of muscle tissue, and the resulting motor activity. It rests and repairs when contact ceases, or the exhausted nerves grow irresponsive. Without contact there could be no life. The body of man is a delicate instrument, played upon by the fingers of the universe, and responding in harmonious motions to the finest touch. But it must have its intervals of rest, in which its relaxed strings can be keyed up again to the concert pitch of active vitality. Could a sleeping body be so situated that no influence, either physical or mental, could act upon it, it could never waken. But it cannot be so situated. In the deepest slumber fine touches of exterior matter constantly seek the nerve extremities. In time the repaired frame grows again responsive. Now a touch calls a muscle into action. Now an impression makes its way through the brain to the mind. The heart, which had lost vitality through an excess of oxidation, during the day, has regained it by an excess of nutrition during the night. The blood current pours rapidly through the body, the animal energies break into full play, and the daily flow of the tide of life succeeds its nightly ebb.

Protoplasm, whenever so situated as to expose it to external contact, displays the general results above considered. The protoplasm of plants is as sensitive as that of animals, but ordinarily is covered with a more impervious coating, which hinders the communication of vibrations from cell to cell. It is also, probably, less freely permeated by oxygen. Yet leaves have general motions which are instigated, in most cases at least, by external contact. Many leaves move in response to the vibrations of light, and many others in response to touch. Possibly the seemingly definite motions of climbing plants may be thus instigated. In the meat-eating plants the contact influence is often conveyed to considerable distances, but these movements are usually deliberate, as if the partial insulation of the cells hindered their progress. The motor energy is propagated most rapidly in the line of the long diameter of the cells, in which direction there are fewer interruptions to its movement. Many plant motions are known to be due to a peculiar action of elastic cell membranes, and a forcing out of previously absorbed water. This process, which is quite unlike muscular action, it is not necessary to here describe. It is sufficient to know that it results from a change in the character of the cell protoplasm, which is instigated by external irritation.

The final subject to be here examined is the chemical result of this continued oxidation. Degraded organic products must be continually formed. In the gland cells these take the character of special secretions. In the muscles urea is a marked product. But in all cells protoplasm must be reduced, and the most general products of this reduction seem to be the fats, and possibly the starches. Animal fat is doubtless partly derived from plants, but must also be largely of animal origin. In efforts to explain its appearance most anatomists incline to the opinion that clear protoplasm contains invisible or dissolved fat, and that this fat subsequently loses its solubility, and becomes visible as granules or globules. Such is the opinion of Sachs, Kolliker, Rindfleisch and others. But this does not explain its origin. It simply indicates the fact that fat granules constantly appear, with no evident source. Rindfleisch declares that there is no question but that this fat originates in the interior of the cells. Voit shows that fat and milk are formed from albuminous matters, and not from non-nitrogenous principles. Beale describes "milk as a dissolved organ of the body, and not a simple filtration from the blood." He elsewhere ascribes the fatty granules of the cell to death of the protoplasm. Other authors might be quoted if necessary, but the facts of fatty degeneration prove clearly that fat appears as protoplasm disappears, and in a manner to indicate that the former is a product of chemical change in the latter, not that protoplasm is an intimate mixture of albumen and fats, as some authors believe.

In all active animal cells minute granules appear. If nutrition be checked these increase in size, and plainly indicate their fatty nature. In cases of fatty degeneration, or the production of the ordinary fat cells, the conversion of protoplasm into fat continues. Finally the nucleus disappears, and only a spherical mass of fat remains in the cells. The sebaceous glands are constantly occupied in excreting it from the body. Occasionally the milk glands act similarly. Their function is a sort of temporary fatty degeneration of tissue.

Certain interesting experiments on starvation in plants and animals, made by Dr. D. D. Cunningham of India, may be of interest in this connection. He shows that the result of starvation in fungoid plants is principally the conversion of protoplasm into fats, it being ultimately all thus converted. Starvation in animals causes a rapid increase of fat granules in the cells. These cells eventually break up, and discharge their oil globules into the blood serum. The change occurs with least rapidity in connective tissue cells, and most rapidly in active epithelial and blood cells. The protoplasm is converted into oil, at first granules, then globules. Then the cells disappear. Finally the intestinal epithelium disappears, and nutrition becomes impossible.[1]

In old age, when nutrition decreases, fatty degeneration is very frequent. This takes place most particularly in the non-vascular tissues. But it may effect all the tissues of the body, and even the walls of the blood vessels. Fatty metamorphosis always occurs in cases of disproportion between the means of nutrition and the parenchyma to be nourished, and may arise either from decrease of nutrition or increase of parenchyma. When a part is, from any cause, imperfectly nourished, fatty degeneration always occurs.[2]

It would seem, then, as if this was one of the normal results of animal activity. Oxygen incessantly attacks the tissues, reduces their albuminoid molecules, yields animal energy, and leaves fat as the general, and other substances as special, results of its action. Whether the decline from the albuminoid to the fatty stage of chemical condition is made at a single step, or by several successive steps of oxidation, at each of which it may be arrested by nutrition, is a question not easily settled. It is very certain, however, that a synthetic phase of chemical action opposes, or succeeds, this analytic phase. The molecules have been reduced chemically by oxidation. They are rebuilt by nutrition. But at what stage of reduction the combination with nutrient molecules takes place, whether at the fatty, or some earlier stage, is an open question. So far as indications go it would appear that protoplasm is directly converted by oxidation into a denitrogenized compound. Oxidation seems to take away its nitrogen radical, and nutrition to replace it.

The processes of plant activity become of interest in this connection. Fats frequently appear in the plant cells, but starch, which occurs in limited quantities in animal cells, is the most abundant constituent of those of plants, and the mode of its occurrence is specially interesting. Whatever be the true process of carbon assimilation in the leaves, the fact that the starch product makes its appearance in the interior of cells, and that there is a chemical reduction of the cell protoplasm, is very important. Starch is not directly produced by the union of carbon with some sap molecule, but is apparently the result of some special cell metamorphosis, and on the character of this metamorphosis much light is thrown by Pringsheim's late researches into the nature and changes of chlorophyll.

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[1] Quarterly Journal of Microscopical Science, January, 1880.

[2] E. Rindfleisch, Manual of Pathological Histology, p. 40.

The fact that assimilation takes place only in sunlight is particularly interesting in its bearing on the preceding hypothesis. We seem to have here a special case of contact influence. It is known that plants respire oxygen day and night. This oxygen is mainly employed in the plant interior in yielding force in aid of nutrition. But in the leaves it is otherwise employed, and here we have distinctive waking and sleeping periods. In the dark the whole plant sleeps; nutrition alone goes on. In the light the leaves awake; tissue oxidation is set up. It would appear, then, as if the contact or vibratory influence of the light rays was the agency which set up this special oxidation of protoplasm. Pringsheim has shown that if the light be very intense the oxidation grows so vigorous as to destroy the cells. If there be no light there are no oxidation products. The admission of light yields chlorophyll as its first resultant, this green coloring matter henceforth acting as a protective screen to the cell against the too vigorous action of the light rays. A somewhat later product is the readily oxidizable substance which he names hypochlorin.

These changes are appearently preliminary to the assimilation of carbon. The character of the subsequent changes is not very evident. The respired oxygen apparently effects a reduction of the hypochlorin to a lower stage, and may possibly set free a molecule having a vigorous affinity for carbon, sufficient to overcome its affinity for oxygen, and thus to decompose the carbonic acid molecule. However this be, one thing is certain: the oxidation that takes place yields a quantity of free energy. The sunlight which instigates oxidation, also yields, perhaps as vibration of the cell contents, a quantity of free energy. The energy thus set free does not manifest itself as mass motion or as temperature. It is undoubtedly consumed in the formation of the starch molecules, and is one of the most important requisites to carbon assimilation. Thus, though the leaves possess the conditions which in animals result in motor activity, the energy set free by the oxidation of their protoplasm is but slightly thus employed, but is locked up in the starch product of assimilation.

In the economy of plant life starch and sugar (its soluble form) are the contributions of the leaf to the growth of the tree. The most important contribution of the root is ammonia, or some resultant nitrogen molecule. The result of the meeting of those two contributions we can but conjecture. There may be something analogous to animal nutrition, in which latter there is a degree of evidence that a nitrogen and a denitrogenized radical unite to form the albuminoid molecule. To this nutritive process oxidation is constantly necessary. The formation of the protoplasm molecule cannot take place except motor energy is supplied, and this energy is furnished by oxidation of some constituent of the sap current.

A rapid résumé of a portion of the argument here developed is desirable. This is in relation to the successive periods of rest and activity which affect all animal life, and which have been recently traced in the life of each separate cell. Each cell has its active and its resting periods. During activity changes rapidly occur, and division takes place. This is always followed by a period of quiescence; in which, perhaps, nutritive assimilation replaces the active oxidation of the preceding period. We may now trace more fully the true relations of the sleeping to the waking condition in animals. It is very probable that oxidation of organic substance never ceases within the animal body; but this oxidation takes two distinct phases, which may be termed primary and secondary oxidation, the former being the reduction of protoplasm, and requiring surface irritation, or its mental resultant, for its active operation; the latter being the reduction of hydrocarbons and other denitrogenized compounds, and acting under other conditions.

Oxygen is not used up in the body immediately upon its introduction. There is some storage process by which it is laid away until required. It has been shown by the experiments of Pettenkoffer and Voit that the expired carbonic acid is no measure of the oxygen simultaneously inspired. During the day the expired carbonic acid is considerably in excess of that due to the oxygen inspired. During the night the opposite is the case, more oxygen is breathed in than is expired. Thus a portion of the oxygen received during sleep seems to be retained in the body, for use during the waking period. It probably partly lies in the blood corpuscles, but it must also be largely laid up in the muscles, from their power of contraction long after removal from the body. Perhaps it is stored in all the protoplasmic tissues.

These facts lead to definite views concerning organic action. Nutrition and oxidation constantly go on, yet each has its two distinct phases. The primary phase of oxidation is accompanied by a secondary phase of nutrition. Protoplasm is oxidized and reduced. Part of the energy yielded is employed in the capture, mastication and digestion of food, its absorption and carriage by the blood, and its storage in the tissues, or in the cells.

During the resting or nutritive period these operations cease. Primary nutrition comes into play, and is aided by secondary oxidation. The products of primary oxidation are again attacked by oxygen, and some of their molecules still further reduced. But this chemical action yields an energy which aids others of their molecules to combine with the stored nutrient molecules, to the reproduction of protoplasm. This is the primary nutritive process. It is a process of double decomposition which is in close accordance with many inorganic chemical actions. There is a splitting asunder of one substance, whose sundered molecules combine with two other attracting substances, to the formation of two new compounds. In this process only a portion of the oxygen received during sleep is employed. The remainder is stored up in the protoplasmic tissues, for use during the waking period.

The true process of organic action may possibly be something like the following: The activity of protoplasm arises from the affinity of oxygen for its nitrogenized element. Oxygen permeates the protoplasm, but its affinity is resisted until vibration, induced by some external irritation, aids its attractive energy. Then the nitrogen molecule is attacked, and nitrogenized waste results. Urea is a constant product of muscle oxidation, and possibly of all oxidation of protoplasm. The denitrogenized remnant of the protoplasm remains in the cell. There are stored up in contact with it nutrient molecules which possess nitrogen, but which need some slight change in condition to give them vital activity. This change is effected by the further decomposition of the denitrogenized product of the previous oxidation. Acted on at once by the affinities of oxygen and of nutriment, it breaks up into two new molecules, one of which combines with oxygen, the other with the nutrient molecule. The energy set free by the oxidation suffices for the purposes of the nutrition process. As a final result we have protoplasm on the one hand, and degradation products, of no further use to the body, on the other. Like urea—the nitrogen waste—this carbon waste is now removed from the body, and the tissues are once more free and in condition for a repetition of the active vital process.

Such, or something not greatly unlike this, seems to be the organic process. Life appears to result from the play of the affinities of oxygen for nitrogen and carbon. Combination of oxygen with nitrogen compounds sets the wheels of life in motion, yielding energy which is free to produce organic motion. Combination with carbon compounds winds up again the clock of life, and prepares for a new period of activity. But the affinity of oxygen for the organic molecules is resisted, and cannot take place effectively except when assisted. Vibratory impulse, resulting from external irritation, aids its affinity for the nitrogen molecule, and induces the active state. Double chemical action aids its affinity for the carbon molecule, which it can attack only by aiding in the reformation of protoplasm. Possibly it may have slight powers of attack when unassisted, but its vigorous action seems to require these aids. And in this fact we have a possible solution of the mystery of life, for it is to some such play of affinities that sensory and motor activities, and the production of new protoplasm, are due, and in this sense organic life is a result of oxygen affinities.

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INDIAN MUSIC.

BY EDWIN A. BARBER.

THE Indian tribes of America possess to-day but a limited knowledge of the art of music, though the Chippewas are said to have employed, to a limited extent, some years ago, a method of notation which was, at least, familiar to the medicine men of the tribe. A manuscript, which the traveler Catlin pro-